NOTES ON THE MOLLUSKS OF THE COLORADO DESERT,—I.

By S. Stillman Berry.

1.—INTRODUCTION.

Topographically, geologically, and biologically, the Colorado Desert is unique among all the very diverse natural areas of the state of California, only its sister desert to the north, the Mojave, affording a partial parallel. It is likewise one of the most interesting of these areas. Nearly every wanderer who has been fated to enter its portals, as even now the present writer, seems to have felt it incumbent upon him to add his mite to the printed record, with the result that an extensive literature of the region is already in existence, and grows apace. Nevertheless, and in face of the fact, this is still in many respects a little known country.[1]

---

[1] In addition to the titles cited in the bibliography, there are a number of works not dealing with the Mollusca which, nevertheless, have such important bearing toward an understanding of the desert and its bionomics, that it seems worth while to include a brief list of a few which have been found particularly helpful in this manner.

Abrams, L.
:10. A phytogeographic and taxonomic study of the southern California trees and shrubs. Bulletin New York Botanical Garden, v. 6, p. 300– 85, pl. A–J, 1910.
:15. The deserts and desert flora of the west. Nature and Science on the Pacific Coast, p. 168–176, pl. 24, San Francisco, 1915.

Atsatt, Sarah M.
:13. The reptiles of the San Jacinto area of southern California. University California Publications, Zoology, v. 12, p. 31–50, November, 1913.

Bryant, H. C.
:11. The horned lizards of California and Nevada of the genera Phrynosoma and Anota. University California Publications, Zoology, v. 9, p. 1–84, text fig. A–B, pl. 1–9, December, 1911.

Grinnell, J.
:13. A distributional list of the mammals of California. Proceedings California Academy Sciences, (4), v. 3, p. 265–390, pl. 15–16, 1913.
:14. An account of the mammals and birds of the Lower Colorado Valley with especial reference to the distributional problems presented. University California Publications, Zoology, v. 12, p. 51–294, text fig. A–I, pl. 3–13, March, 1914.
:15. A distributional list of the birds of California. Pacific Coast

Among major groups of the fauna, this statement is particularly true concerning the Mollusca. The very name "desert" seems to imply a terrain ill suited for these soft-bodied, cool-blooded animals; and it has been only a few years since that we began to realize that aridity, far from prohibiting life of this sort, actually has seemed in many instances to tend directly toward an increase in the variety and richness of the fauna. Whether this would be true in that classical type of desert which consists only of long

Avifauna, no. 11, p. 1–217, pl. 1–3, 1915.
:15a. The vertebrate fauna of the Pacific Coast. Nature and Science on the Pacific Coast, p. 104–114, pl. 12–13, San Francisco, 1915.
GRINNELL, J., & SWARTH, H. S.
:13. An account of the birds and mammals of the San Jacinto area of southern California with remarks upon the behaviour of geographic races on the margins of their habitats. University California Publications, Zoology, v. 10, p. 197–406, text fig. 1–3, pl. 6–10, October, 1913.
GRINNELL, J., and CAMP, C. L.
:17. A distributional list of the amphibians and reptiles of California. University California Publications, Zoology, v. 17, p. 127–208, text fig. 1–14, July, 1917.
HALL, H. M.
:02. A botanical survey of San Jacinto Mountain. University California Publications, Botany, v. 1, p. 1–140, pl. 1–14, June, 1902.
HALL, H. M. & GRINNELL, J.
:19. Life-zone indicators in California. Proceedings California Academy Sciences, (4), v. 9, p. 37–67, June, 1919.
MACDOUGAL, D. T., et al.
:14. The Salton Sea. Carnegie Institution Washington Publication 193, p. i–xi, 1–182, maps, pl. 1–32, June, 1914.
:17. A decade of the Salton Sea. Geographical Review, v. 3, p. 457–473
:17. A decade of the Salton Sea. Geographical Review, v. 3, p. 457–473 text fig. 1–8, June, 1917.
MEARNS, E. A.
:07. Mammals of the Mexican boundary of the United States. A description catalogue of the species of mammals occurring in that region; with a general summary of the natural history, and a list of trees. Part 1—Families Didelphiidae to Muridae. United States National Museum Bulletin 56, p. i–xv, 1–530, text fig. 1–125, pl. 1–13, 1907.
PARISH, S. B.
:07. Contributions toward a knowledge of the genus Washingtonia. Botanical Gazette, v. 44, p. 408–434, December, 1907.
RICHARDSON, C. H., JR.
:12. The distribution of Hyla arenicolor Cope, with notes on its habits and variations, American Naturalist, v. 46, p. 605–611, map, October, 1912.
VAN DENBURGH, J.
'97. The reptiles of the Pacific Coast and Great Basin. Occasional Papers California Academy Sciences, v. 5, 1–236, numerous text figs., September, 1897.
WILLIAMSON, R. S.
'55. Report of explorations in California for railroad routes, to connect with the routes near the 35th and 32d parallels of North Latitude. Reports of explorations and surveys . . . for a railroad . . . to the Pacific Ocean . . . in 1853–4, v. 5, pt. 1, p. 1–43, pl. 1–12, maps, cuts, 1851 (Date of complete volume, 1856).

unbroken stretches of flattish sandy country may well be doubted, but where, as here, the many mountain ranges form islands of a slightly less degree of desiccation, the snails are given a chance to maintain a figurative toehold, and in time to become better adapted their desert environment, while meanwhile the principle of isolation comes into play. It is only recently that it has been discovered that if numbers of species are to be regarded as criteria, the true molluscan metropolis of North America is not in tropic Florida, nor in the swampy lowlands of Louisiana and Texas, nor in the forests of the northwest, but in dry Arizona, where every mountain range, in some cases almost every canyon, seems to harbor its own peculiar land-snail fauna. There are of course numerous widespread species, principally minute, but the multitude are surprisingly local in their distribution. While it is perhaps not to be expected that the region under discussion will prove to rival southern Arizona, enough has now been done to show that further exploration will yield substantial rewards. The land snails naturally constitute the great unknown. Nevertheless fluviatile mollusks likewise are more important and numerous than might be suspected.

THE COLORADO DESERT.—The term "Colorado Desert" has been somewhat variously applied by different writers, but the most logical as well as historically the most precise use of the name is undoubtedly the definition given by its original proponent, Prof. W. P. Blake, who writes (:14, p. 6–7; :15, p. 21–22):—

"The name '*Colorado Desert*' was given to this region by the writer in 1853."

"This was before the State of Colorado received its name. It was deemed most appropriate to connect the name of the Colorado River with the region inasmuch as the desert owes its origin to the river by the deposition of alluvions and the displacement of the sea-water."

"A tendency is shown by some writers to extend the area known as the Colorado Desert so as to include the arid regions north of it, especially the mountainous region along the Colorado and the Mojave, partly known today as the 'Mojave Desert.' This was not the intention or wish of the author of the name. It was intended to apply it strictly to the typical desert area of the lacustrine clays and alluvial deposits of the Colorado where extreme characteristic desert conditions prevail, such as arid treeless plains, old lake beds and sand hills—such conditions as are found in the Sahara of Africa and in the delta regions of the Nile. I should also

include the bordering detrital slopes from the contiguous mountains. So restricted, the area is practically coterminous with the ancient beach-lines and terraces of the lakes whic hoccupied the valley."

"Its area is estimated at not less than 2,100 square miles, its breadth east and west opposite Carrizo Creek about 33 miles. Its height above tide ranges from 135 feet above sea-level at Yuma to an average of 42 feet following the old shore line of Cahuilla Lake, and to minus 187 feet, now partly submerged."

The only possible criticism of this definition is that restricted in this way it becomes too purely geological and genetic for convenient application to a physiographic phenomenon like a desert. Certainly a broadly conceived faunistic study of the region cannot so confine itself. For the purpose of such a study most workers will find it more practicable to define the region as that roughly enclosed on the north and northeast by the desert slopes of the San Bernardino Mountains and the divide which is formed by their depauperate southeastern spurs, the Cottonwood, Chuckawalla, and Chocolate Mountains, and which separates the Cahuilla Basin from the more diffused Mojave Desert further north; on the east and southeast by the Colorado River; and on the southwest and west by the eastern escarpment of the Peninsular Range and the Santa Rosa and San Jacinto Mountains. The entire area will even then fall within the confines of the single major life zone known as the Lower Sonoran, unless one prefers to draw the desert boundary far enough up the circumventing mountains to include some portions of the Upper Sonoran zone.

Thus understood the general outline of the desert is roughly triangular, with the base on the Colorado River, the apex at the San Gorgonio Pass, and comprising within it the eastern portion of Riverside County, the whole of Imperial County, and a little of the eastern edge of San Diego County, California, while the southern corner of the triangle juts over into the Mexican territory of Lower California. San Bernardino County is barely touched in the vicinity of the Morongo. If Death Valley be excepted, the region is doubtless quite unique within the borders of the United States, if not in the world. From the floor of the Salton Sink which lies 265 feet below sea level, there is a gradual ascent of the desert floor to a line varying from nearly sea-level to about 2,500 feet along the base of the mountains, which then rise abruptly to varying heights, the most loftly being San Jacinto Peak, with an elevation of 10,805 feet, and San Gorgonio Peak, 11,485 feet high. By reason of their prevailingly granitic formations, lack of foot-

hills, and consequent abrupt ascent from the desert floor, the desert mountain ranges show a common peculiarity of contour which is pictured with especial felicity by J. Smeaton Chase in his very readable book, "California Desert Trails" (:19, p. 7):—

"The characteristic contour form of the desert mountain ranges is another element in the beauty of desert color. Like geological models set on a table, they stand up sharply defined from the general level, arresting the glance with new, conspicuous effects. No gently modelled approaches prepare the eye for the change of plane. From gray or drab expanse of sand they rear up wall-like profiles of red or ochre. Perspective is dwarfed by the clearness of air, increasing the sense of verticality. Instead of rising from the desert, these mountains stand upon it, explicit, bald, almost artificial."

Mt. San Jacinto furnishes the supreme example of these sudden changes in level. Measuring horizontally north on the topographic map from the peak to various points in Snow Creek Canyon and vicinity one finds a span of but 3¾ miles from the summit to the 2,000-foot contour, or of only 5 miles to the 1,400-foot contour, a net drop of 9,405 feet. To the east of the peak the fall to the 500-foot contour takes place in less than seven horizontal miles. Very frequently of course less extreme descents take place much more abruptly.

Occurrence of Land Snails.—It has been deemed best to include the foregoing brief account of the region because an understanding of its peculiar topography is of the utmost importance to the malacologist in view of the fact that the land snail fauna of the desert, so far as known, is confined wholly to these steep mountain slopes. From the Colorado Desert in the technically geological sense of Blake, endemic, terrestrial mollusks are probably wholly lacking. The massive granitic fragments which litter the mountain bases, the obliquity, with reference to the rays of the sun, of all slopes but the hot southern exposures, and the modicum of moisture, however scanty, which seeps down from the heights, all serve to render possible the continued existence in such situations of these remarkably adapted xerobic creatures in a way not possible, even for them, on the scorching floor of the desert a stone's toss away. West of Indian Well I found myself literally able to collect *Micrarionta xerophila* from the steep mountain slope while standing with both feet firmly planted on

the valley floor, where the most careful search discovered for us not a trace of a snail. No doubt there are many places where a repetition of this experience would be possible. In the deep canyons which gash these precipitous ranges conditions are frequently rather more favorable for land mollusks, though even here one encounters them on the slopes and rarely if at all along the water-courses themselves.

Although sometimes quite abundant, at least in the form of chalky-white dead shells scattered about the surface of the ground, they are often so rare that living specimens become quite difficult to detect. Consequently but few have found their way into the hands of students. If for practical reasons the now almost legendary *Helix damascenus* of Gould[2] be excepted, Bowers' discovery near Indio of the snail described by Yates in 1890 as *Helix Carpenteri*, var. *Indioensis*, but first recorded by Orcutt in 1889, was the earliest to be published. Almost simultaneously Orcutt reported the occurrence of a form of *Helix* from Snow Creek and Palm Canyons which probably represented the species which Bartsch described from Palm Springs specimens in 1903 as *Sonorella walcottiana*. Meanwhile, Bryant in 1900 had described two snails from the "San Jacinto Mts." under the names *bowersi* and *harperi*. Although very insufficiently known, at least one of these and quite possibly both belong to the same group of characteristic desert snails as those already noted. In 1904, Bartsch described *Sonorella baileyi orcutti* from material collected by Orcutt "in the Colorado Desert." All the foregoing seem to have been described or recorded in each instance from dead shells only. It has only been very recently that Dr. Emmet Rixford collected living examples of *wolcottiana* at Palm Springs which Pilsbry (:18) has shown to possess the anatomical characteristics of the genus *Micrarionta*. And this, so far as I can discover, quite completes the record, although a number of allied species of *Micrarionta* have been described from the ranges of the adjoining Mojave and Arizona deserts.

---

[2] MICRARIONTA (?) DAMASCENUS (Gould 1856).

1856. *Helix damascenus* Gould, Proc. Bost. Soc. Nat. Hist., v. 6, p. 11.

1862. *Helix pandorae* (pars) Gould, Otia Conch., p. 219 (mere mention).

1869. *Helix pandorae* (pars) Binney, in Binney & Bland, Land & Fr. W. Sh. N. Am., 1, p. 180.

1892. *Helix pandorae* var. *damascenus* Cooper, Zoe, v. 3, p. 18 (brief note).

The original locality is given by Gould as "Desert region east of California," collected by Dr. Frick. Unless Frick's record is very far astray, the species can have little to do with *Micrarionta pandorae* (Forbes).

With the exception of the small and in many respects peculiar species which is described in the present paper from Whitewater Canyon, the desert helicoids seem invariably to occupy the same sort of situations and to have essentially similar habits. They have not yet been discovered deep down in rockslides like so many of the Arizonian species, but generally aestivating under blocks and boulders of granite, or among the loose soil and rubble in the crevices thereof. When active they frequently come to the surface, where at favorable moments they may be found in the open, crawling. Beyond this little is known of their habits, their food supply, or their position in the general bionomic economy, as is a natural sequence of the fact that without any doubt the very great majority of existing species are still unknown to us in any way whatsoever.

The distribution of the desert palm (*Neowashingtonia filamentosa*) has been plotted out with a view to showing its probable relationship to the ancient shore line of the Gulf of California which seems to have extended well up into this basin at no very distant period. Whether anything of the sort will be possible with the land snails remains to be seen, but it is at least an interesting speculation whether the characteristic desert *Eremarionta* was not itself, at one time, a maritime group as the more typical section of *Micrarionta* still remains to this day.

Of the numerous North American groups of land snails smaller than the helicoids, none appears to have been recorded from the area under discussion hitherto.

Freshwater Mollusca.—In nearly complete contrast to the land snails, interest in the fresh-water Mollusca necessarily centers almost exclusively in the relict-covered bed of the ancient Lake Cahuilla, in other words, the Colorado Desert in the exact original sense of that term. The wonder caused by the enormous numbers of the stranded shells which fill the soil in many parts of the valley, and the interest aroused by the eventual discovery of many of the same species still flourishing in certain of the outlying springs and rivulets has long attracted attention to this part of the fauna. The pioneer publication dealing with a fresh-water mollusk of this region was probably that of Lea ('52), who described his *Anodonta Californiensis* from the "Rio Colorado, California." A few years later Gould ('55) applied names to five species of fresh-water

mollusks from the desert proper, most of which are still in use for those species. Among the more important works since that time are a further paper by Gould ('56), a brief account by Orcutt ('89), some incidental notes by Dall ('96), and Pilsbry ('99), and especially the succession of papers by Stearns ('79, '82, '83, '83a, '93) which finally culminated (:01) in a comprehensive monograph of the fresh-water mollusks based principally upon the desert fossils. The occurrence of these fossils in windrows, at varying depths in the friable soil, and in the travertine of the terraces, has been of the greatest interest to the geologist engaged in tracing the past history of the basin, and they therefore receive at least passing mention in many general works on the Desert. There is little doubt that a more truly exhaustive study than has yet been attempted will be fruitful of results of the utmost value, not alone to the geologist, but to the systematist, the ecologist, and, thanks to the extraordinary character of the variations passed through by some of the forms, perhaps even to the student of evolution and the geneticist.

Except in the bibliography given, the present paper touches on the fresh-water mollusks only incidentally.

2.—BIBLIOGAPHY OF MOLLUSCA OF THE COLORADO DESERT.

A.—TAXONOMIC

ANON.

'56. Catalogue of the geological collection with descriptions of several of the specimens. Reports of explorations and surveys . . . for a railroad . . . to the Pacific Ocean . . . in 1853–4, vol. 5, pt. 2. Appendix, p. 344–358, 1856. (List of fossil and recent mollusks given on p. 350–354).

BARTSCH, P.

:03. A new landshell from California. Proceedings Biological Society Washington, vol. 16, p. 103–104, June, 1903. (*Sonorella walcottiana* n. sp. described from Palm Springs).

:04. Sonorella wolcottiana—a correction. Proceedings Biological Society Washington, vol. 17, p. 101, April, 1904.

:04a. Notes on the genus Sonorella, with descriptions of new species. Smithsonian Miscellaneous Collections (Quarterly Issue), vol. 47, p. 187–200, pl. 28–33, October, 1904. (*Sonorella baileyi orcutti* n. subsp. described from Colorado Desert, with discussion and figures of allied Desert species).

BINNEY, W. G.

'65. Land and fresh water shells of North America. Part II. Pulmonata limnophila and thalassophila. Smithsonian Miscellaneous Collections, vol. 7, no. 143, p. i–ix, 1–171, text fig. 1–261, September, 1865.

'65a. Land and fresh-water shells of North America. Part III. Ampullariidae, Valvatidae, Viviparidae, fresh-water Rissoidae, Cyclophoridae, Truncatellidae, fresh-water Neritidae, Helicinidae. Smithsonian Miscellaneous Collections, vol. 7, no. 144, p. i–viii, 1–120, text fig. 1–232, September, 1865.

BRYANT, F. W.

:00. Description of a new Californian land shell. Nautilus, vol. 13, p. 122, March, 1900. Repr. in West American Scientist, vol. 11, p. 31, May, 1900. (*Epiphragmophora Bowersi* n. sp. described from "San Jacinto Mts.")

:00a. Epiphragmophora harperi, n. sp. Nautilus, vol. 13, p. 143–144, April, 1900. Repr. in West American Scientist, vol. 11, p. 30, May, 1900. (*Epiphragmophora harperi* n. sp. described from "San Jacinto Mts.").

CARPENTER, P. P.

'64. A supplementary report on the present state of our knowledge with regard to the Mollusca of the west coast of North America. Report British Association Advancement Science, 1863, p. 517–686, August, 1864. Repr. in Smithsonian Miscellaneous Collections, p. 1–172, December, 1872. (Some of Gould's fresh-water species noted on p. 593, 674, 676 [79, 160, 162]).

COOPER, J. G.

'92. Catalogue of the land and fresh-water Mollusca of Lower California. Zoe. vol. 3, p. 12–25, 1892. (Contains notes on *Helix carpenteri*, var. *indioensis* Yates, and certain fresh water species of the Colorado Desert).

CONRAD, T. A.

'55. Description of a new species of Melania. Proceedings Academy Natural Sciences Philadelphia, vol. 7, p. 269, 1855. (*Melania exigua* n. sp. described from Colorado Desert).

DALL, W. H.

'96. Report on the mollusks collected by the International Boundary Commission of the United States and Mexico, 1892–1894. Proceedings United States National Museum, vol. 19, p. 333–379, pl. 31–33, 1896. (Contains notes on a number of the desert mollusks).

FRAUENFIELD, G. RITTER VON.

'63. Vorläufige Aufzählung der Arten der Gattungen Hydrobia Htm. und Amnicola Gld. Hldm., in der Kaiserlichen und in Cuming's Sammlung. Verhandlungen d. k. k. zoologisch-botanischen Gesellschaft in Wien, 1863, p. 1025. (*Bythinella seemani* n. sp. described from Durango, Northwestern Mexico).

GOULD, A. A.

'55. New species of land and fresh-water shells from western (N.) America. Proceedings Boston Society Natural History, vol. 5, p. 126–130, February–March, 1855. (Contains descriptions of following new species of fresh water mollusks from various localities in the Colorado Desert: *Physa humerosa, Planorbis ammon, Planorbis gracilentus, Amnicola protea, Amnicola longinqua*).

'56. [Descriptions of shells]. Proceedings Boston Society Natural History, vol. 6, p. 11, October, 1856. (*Helix damascenus* n. sp. described from "Desert region east of California." May be extralimital to present paper).

'56a. Catalogue of the recent shells, with descriptions of the new species. Reports of explorations and surveys . . . for a railroad . . . to the Pacific Ocean . . . in 1853–4, vol. 5, pt. 2, Appendix, p. 330–336, pl. 11, 1856. (Contains further descriptions and figures of mollusks named in '55).

'62. Otia conchologica: descriptions of shells and mollusks, from 1839 to 1862. p. 1–256, 8vo, Boston, 1862. (Contains reprints of Gould, '55 and '56).

HANNIBAL, H.

:12. The aquatic molluscs of southern California and adjacent regions, a Transition fauna. Constituting Part II of "A census of the land and fresh-water mollusks of south-western California." Bulletin Southern California Academy Sciences, vol. 11, p. 18–46, pl., January, 1912.

:12a. A synopsis of the recent and tertiary fresh-water mollusca of the Californian Province, based upon an ontogenetic classification. Proceedings Malacological Society London, vol. 10, p. 112–211, pl. 5–8, June–September, 1912.

LEA, I.

'52. Descriptions of new species of the family Unionidae. Transactions American Philosophical Society, (2), vol. 10, p. 253–294, pl. 12–29, 1852. (Same paper appears in Observations on the genus Unio, etc., vol. 5, p. 1–62, pl. 12–29, 1852. (*Anodonta Californiensis* n. sp. described from "Rio Colorado, California").

ORCUTT, C. R.

'89. Recent and sub-fossil shells of the Colorado Desert. West American Scientist, vol. 6, p. 92–93, August, 1889.

'89a. Editorial. West American Scientist, vol. 6, p. 95–96, August, 1889. (On p. 96 notes discovery of a new *Helix* at Indio by Dr. Bowers.)

'90. West American notes. Nautilus, v. 4, p. 67–68, October, 1890. (Contains references to *Helix indioensis* Yates and other desert mollusks).

'91. Contributions to West American Mollusca.—1. West American Scientist, vol. 7, p. 222–224, September, 1891. (Contains note on *Helix carpenteri* var. *indioensis* Yates).

:00. Notes and news. West American Scientist ,vol. 11, p. 70, July, 1900 (appears also in *id.*, vol. 11, p. 28, August, 1900). (Contains notes (unimportant) on *Epiphragmophora Harperi* and *Bowersi*, Bryant).

PILSBRY, H. A.

'97–'98. A classified catalogue of American land shells, with localities. Nautilus, vol. 11, p. 45–48, 59–60, 71–72, 83–84, 93–96, 105–108, 117–120, 127–132, 138–144, August, 1897–April, 1898, Reprinted, with corrections, by H. A. Pilsbry and C. W. Johnson, p. 1–35, Philadelphia, 1898.

'99. Catalogue of the Amnicolidae of the western United States. Nautilus, vol. 12, p. 121–127, March, 1899. (Contains notes on *Paludestrina longinqua, protea*, etc.).

:00. Sonorella, a new genus of Helices. Proceedings Academy Natural Sciences Philadelphia, 1900, p. 556–560, pl. 21, November, 1900. (On p. 560 includes *Helix indioensis* Yates in *Sonorella*. .Occurrence of genus elsewhere in southern California anticipated).

:18. On the generic position of Sonorella wolcottiana Bartsch. Pro-

ceedings Academy Natural Sciences Philadelphia, 1918, p. 139–140, text fig. 1, 1918. (*S. wolcottiana* referred to *Micrarionta*).

:21. Land shells from Palm Canyon, California, and the Grand Canyon. Nautilus, vol. 35, p. 48, October, 1921. (Contains brief habit note on *Micrarionta wolcottiana*).

STEARNS, R. E. C.

'79. Remarks on fossil shells from the Colorado Desert. American Naturalist, vol. 13, p. 141–154, 12 figs., March, 1879.

'82. On the history and distribution of the fresh-water mussels and the identity of certain alleged species. Proceedings California Academy Sciences, p. 1–21, pl. 1–6, 1882. (Unionids of Colorado Desert dealt with on p. 4, 5, 6, 8, 9).

'83. Description of a new hydrobiinoid gasteropod from the mountain lakes of the Sierra Nevada, with remarks on allied species and the physiographical features of said region. Proceedings Academy Natural Sciences Philadelphia, 1883, p. 171–176, 1 text fig., 1883. (On p. 172–173 are some remarks on the Colorado Desert Paludestrinae, especially *Tryonia*).

'83a. On the shells of the Colorado Desert and the region farther east. American Naturalist, vol. 17, p. 1014–1020, text fig. 1–3, October, 1883.

'93. Report on the land and fresh-water shells collected in California and Nevada by the Death Valley Expedition, including a few additional species obtained by Dr. C. Hart Merriam and assistants in parts of the southwestern United States. North American Fauna, no. 7, p. 269–283, text fig. 1–2, May, 1893. (Deals largely with Mojave Desert and Inyo County fauna, but on p. 278 notes occurrence of living *Bythinella protea* at Indian Springs, near Salton).

:01. The fresh-water shells of the Colorado Desert, their distribution, environment, and variation. Proceedings United States National Museum, vol. 24, p. 271–299, text fig. 1–9, pl. 19–24, 1901.

STIMPSON, W.

'65. Diagnoses of newly discovered genera of gasteropods, belonging to the sub-family Hydrobiinae, of the family Rissoidae. American Journal Conchology, vol. 1, p. 52–54, pl. 8, fig. 1, February, 1865. (*Tryonia clathrata* n. sp. described from "Basin of the Colorado Desert;" "semi-fossilized.")

'65a. Researches upon the Hydrobiinae and allied forms; chiefly made upon materials in the Museum of the Smithsonian Institution. Smithsonian Miscellaneous Collections, p. 1–59, text fig. 1–29, August, 1865. (Includes account of *Tryonia clathrata*, etc.).

YATES, L. G.

'90. A new variety of Helix carpenteri from southern California, Nautilus, vol. 4, p. 51–52, September, 1890. (*Helix carpenteri*, var. nov., described from near Indio, but not named).

'90a. A new variety of Helix. Nautilus, vol. 4, p. 63, October, 1890. (*Helix carpenteri* var. *indioensis* nov. described from near Indio).

B—NON-TAXONOMIC WORKS OF PRESENT INTEREST BECAUSE OF REFERENCES TO OCCURRENCE OF FOSSIL FRESH-WATER MOLLUSKS.

BLAKE, W. P.

'57. Geological report. Reports of explorations and surveys . . . for a railroad . . . to the Pacific Ocean . . . in 1853–4, vol. 5, pt. 2, p. i–xvi, 1–310, pl. 1–13, charts, maps, cuts, 1857. (An important pioneer work; the Colorado Desert dealt with on p. 89–125 (Ch. VIII–X), 137–138, 142, 144, 174–176, 189, 228–252 (Ch. XVII), 280–281, 308,309, etc; fossil mollusks noticed on p. 97, 101, 103, 109, 235, 239).

:14. The Cahuilla Basin and Desert of the Colorado. Carnegie Institution Washington Publication 193, p. 1–12, pl. 1–2, June, 1914. (A somewhat abridged edition of the following paper; fossil fresh-water shells briefly noticed on p. 3–4).

:15. Sketch of the region at the head of the Gulf of California, a review and history. In Cory, H. T., The Imperial Valley and the Salton Sink, pt. 1, p. 1–35, 1915. (Occurrence of fossil fresh-water shells noticed on p. 4, 7, 14, 17).

CHASE, J. S.

:19. California desert trails. p. 1–387, 32 pls. 8 vo, Boston and New York, 1919. (Occurrence of fossil fresh-water shells referred to on p. 114, 128, 179, 195, 262, 265).

FREE, E. E.

:14. Sketch of the geology and soils of the Cahuilla Basin. Carnegie Institution Washington Publication 193, p. 21–33, pl. 6–8, June, 1914 (P. 25–29 contains a valuable discussion of the origin of the Basin, the author doubting its ever having been part of the Gulf; fresh-water molluscan fossils mentioned on p. 26).

HANKS, H. G.

'82. Mud-volcanoes and the Colorado Desert. Second Annual Report California State Mineralogist, p. 227–240, 1882.

JAMES, G. W.

:06. The wonders of the Colorado Desert (Southern California), its rivers and its mountains, its canyons and its springs, its life and its history, pictured and described, including an account of a recent journey made down the overflow of the Colorado River to the mysterious Salton Sea. 2 vols. (vol. 1, p. i–xl, 1–270; vol. 2, p. i–xiv, 271–547), many illustrations, 8 vo, Boston, 1906. (Fresh-water molluscan fossils noticed on p. 5, 25–26 29, 31, & 102 of vol. 1).

JAMES, J. F.

'82. The Colorado Desert. Popular Science Monthly, vol. 20, p. 384–390, January, 1882. (On p. 387 refers to occurrence of *Anodonta Californiansis, Amnicola longinquas, Tryonea protea,* and *Physa humerosa,* as fossils).

JONES, J. C.

:14. The tufa deposits of the Salton Sink. Carnegie Institution Washington Publication 193, p. 79–83, June, 1914. (Occurrence of fresh-water snail shells in tufa of prehistoric Blake Sea at Travertine Point, etc., noted on p. 81, 83).

MacDougal, D. T.

:14. General discussion. Carnegie Institution Washington Publication 193, p. 173–182, June, 1914. (An important paper; mentions occurrence of shells of fresh-water mollusks in the travertine on p. 173).

:15. The Salton Sea. American Journal Science, (4), vol. 39, p. 231–250, text fig. 1–6, March, 1915. (Occurrence of fossil fresh-water mollusks noticed on p. 233).

Mendenhall, W. C.

:09. Ground waters of the Indio Region, California, with a sketch of the Colorado Desert (60th Congress, 2d Sess., House of Representatives Document 1296) United States Geological Survey Water-Supply Paper 225, p. 1–56, text fig. 1–5, pl. 1–12, 1909. (Occurrence of shells of fresh-water mollusks on floor of desert mentioned on pp. 18, 19).

Orcutt, C. R.

'90. The Colorado Desert. West American Scientist, vol. 7, p. 55, 1890.

'90. The Colorado Desert. Tenth Annual Report California State Mineralogist, p. 899–919, 1890.

:01. The Colorado Desert. West American Scientist, vol. 12, p. 2–14, July, 1901.

Parish, S. B.

:14. Plant ecology and floristics of Salton Sink. Carnegie Institution Washington Publication 193, p. 85–114, June, 1914. (On p. 85 mentions occurrence of shells of fresh-water mollusks in the soil).

Veatch, J. A.

'57. Mud volcanoes of the Colorado Desert. Proceedings California Academy Sciences, vol. 1, p. 104–108, 1857.

C.—WORKS MORE OR LESS EXTRA-LIMITAL, BUT WITH IMPORTANT BEARING.

Clapp, G. H.

:07. Epiphragmophora (Micrarionta) hutsoni n. sp. Nautilus, vol. 20, p. 136–137, pl. 9, fig. 1–4, April, 1907.

:08. New land shells from Arizona and New Mexico. Nautilus, vol. 22, p. 76–78, 96, pl. 7, pl. 8, fig. 1–3, December 1908 to March 1909.

Edson, H. M., & Hannibal, H.

:11. A census of the land and fresh-water mollusks of southwestern California. Part 1—Land Mollusca. Bulletin Southern California Academy Sciences, vol. 10, p. 47–64, 1 pl., July, 1911. (P. 56–57 records *Thysanophora ingorsolli* from South Mission Canyon, San Bernardino Mts.).

Lewis, J.

'75. [Anodonta dejecta nov.] Field and Forest, vol. 1, p. 26, 1875.

'75. Description of a new species of Anodonta. In Yarrow, H. C.,—Report upon the collections of terrestrial and fluviatile Mollusca made in portions of Colorado, Utah, New Mexico, and Arizona, during the years 1872, 1873, and 1874—Final Report United States Geological Survey West of the 100th Meridian [Wheeler Exp.], vol. 5, p. 952–953, 1875. (*Anodonta dejecta* n. sp.).

Pilsbry, H. A.

:13. Notes upon some Lower Californian Helices. Proceedings Academy

Natural Sciences Philadelphia, 1913, p. 380–393, text fig. 1–3, pl. 15–16, July, 1913. (Contains some valuable general notes on *Micrarionta*).

:19. A new Californian Micrarionta. Nautilus, vol. 33, p. 53, October, 1919. (*Micrarionta rixfordi* n. sp. described from 10 m. west of Twenty-nine Palms).

PILSBRY, H. A., & FERRISS, J. H.

:08. A new Micrarionta from Arizona. Nautilus, vol. 21, p. 134–136, pl. 11, fig. 6–10, April, 1908. (Paper contains some valuable general notes on genera *Micrarionta* and *Sonorella*).

SIMPSON, C. T.

'93. A new Anodonta. Nautilus, vol. 6, p. 134–135, April, 1893. (*Anodonta Mearnsiana* n. sp. described from San Bernardino Ranch, Mexican Boundary, Arizona; = *dejecta* Lewis).

'94. Types of Anodonta dejecta rediscovered. Nautilus, vol. 8, p. 52–53, September, 1894.

3.—SPECIES COLLECTED IN THE COLORADO DESERT IN 1919 AND 1920, WITH NOTES ON OTHERS.

SOURCE OF MATERIAL.—In March, 1919, Mr. George Willett of Los Angeles visited the Desert in the neighborhood of Palm Springs and Indian Well, and made a small but interesting collection of land snails, including some "live shells" of *Micrarionta wolcottiana*, which he kindly turned over to the present writer for study. A year later Mr. Allyn G. Smith of Redlands and Berkeley made a brief stay in the same region. He returned with so many interesting specimens, including the most remarkable find of living *wolcottiana* hitherto made, that early in April Mr. Smith, Mr. J. Stanley Ferguson of Redlands, and the writer, with automobile aid, undertook a three-day reconnaissance of the upper end of the desert, collections being made at sixteen stations. Although but ten species of mollusks were taken on this expedition, two of these prove to be undescribed, and another constitutes a new record for the state of California. All told, six of the ten species are additions to our list of the Desert fauna. This material now becomes the principal basis of the present paper, although a series of specimens received from the California Academy of Sciences through the kindness of Dr. Barton Warren Evermann, Director, and Mr. W. W. Sargeant, Secretary, and a specimen kindly given by Mr. C. R. Orcutt, are also considered. I am happy to acknowledge my indebtedness to all these gentlemen, as well as to Dr. Emmet Rixford of San Francisco, who kindly loaned me some useful comparative material from his own collection. I am under obligation to Dr.

Joseph Grinnell of the Museum of Vertebrate Zoology of the University of California for the use of the accompanying outline map.

LIST OF STATIONS, WITH DATA.—Although collecting was done in three groups of mountains, the San Bernardino, San Jacinto, and Santa Rosa ranges,[3] all the localities visited are within the limits of Riverside County, California and in the border zone of the Colorado Desert.

On the expedition participated in by the writer land snails were taken at fourteen stations, namely Stations I, II, III, IV, VI, VII, VIII, IX, X, XI, XII, XIV, XVI, and XVII. Freshwater mollusks were taken at three stations, XII, XIII, and XV. One station, V, yielded no collections. Certain stations which were worked by only one of the party are indicated accordingly.

Station I. Under stones and shrubs on steep talus slope of decomposed granite, west side of Whitewater Canyon, about one mile above mouth, San Bernardino Mts.; alt. 1,700 ft.; April 1, 1920. (Plate VIII, fig. 1.)

Station II. Among loose leaves and mould under small tree (probably *Rhus* sp.) on rough wall of small side canyon on east side of Whitewater Canyon, near first principal bend, San Bernardino Mts.; alt. 1,800 ft.; April 1, 1920. (Plate VIII, fig. 2).

Station III. Base of west wall Whitewater Canyon, nearly opposite Station II, San Bernardino Mts.; alt. 1,700 ft.; April 1, 1920; A. G. Smith. (Plate VIII, fig. 1).

Station IV. Among granite blocks on lower portion of slope, base of San Jacinto Mts., back of Palm Springs; alt. 500 ft.; April 1, 1920; S. S. Berry.

Station V. Point Happy, Santa Rosa Mts., east of Indian Well; alt. 200–400 ft.; search at night by aid of electric flash-lamp yielded no results; poor place; April 1, 1920; A. G. Smith.

Station VI. Among granite rocks at head of cove in spur of Santa Rosa Mts., southeast of Indian Well; alt, 250–300 ft.; April 2, 1920; slope steep, dry, and with little vegetation.

[3] So far as I can discover there is little to be gained by the prevailing recognition of the San Jacinto and Santa Rosa mountain groups as separate ranges. Palm Canyon or it might be more explicit to say, Palm *Creek*, is the only distinguishable boundary between them. Consequently, in clinging to the standard terminology, one must accredit all stations east of this creek to the Santa Rosa, west of it, to the San Jacintos.

Station VII. Among granite rocks on steep slope close to Highway about 5 miles west of Indian Well, Santa Rosa Mts.; alt. 400–600 ft.; April 2, 1920; little moisture, vegetation scanty.

Station VIII. Among granite rocks on west slope of promontory of Santa Rosa Mts. across valley from Palm Springs; alt. 500 ft.; April 2, 1920; dry; poor situation.

Station IX. Among shrubs and loose rocks on east slope of West Fork of Palm Canyon, San Jacinto Mts.; alt. 750 ft.; April 2, 1920, S. S. Berry.

Station X. On ridge above the Hermit's cabin, west slope of Palm Canyon, San Jacinto Mts.; alt. 100–1,100 ft., April 2, 1920, A. G. Smith.

Station XI. East slope Palm Canyon, above junction with Little Palm Creek, Santa Rosa Mts.; alt. 900–1,300 ft.; April 2–3, 1920; slope covered with large rocks, shrubs, cacti, and smaller plants; search made from 9:30 to 10:00 P. M. by aid of electric flash-lamp, and by daylight from 6:00 to 10:00 A. M. (Plate VIII, fig. 3; Plate IX, fig. 1).

Station XII. Drift of storm rivulets along west side of Palm Creek just above junction with Little Palm Creek, San Jacinto Mts.; alt. 900 ft.; April 3, 1920. (Plate IX, fig. 1).

Station XIII. Little Palm Creek, just above junction with main stream, Santa Rosa Mts.; alt. 900 ft.; April 3, 1920. (Plate I, fig. 3).

Station XIV. Moist slope, upper Little Palm Canyon, Santa Rosa Mts.; alt. 1,200 ft.; April 3, 1920; A. G. Smith.

Station XV. Spring on east slope of Palm Canyon below junction with Little Palm Creek, Santa Rosa Mts.; alt. 850 ft.; April 3, 1920.

Station XVI. Marshy spot on west slope of Palm Canyon, San Jacinto Mts., alt. 800 ft.; April 3, 1920; A. G. Smith.

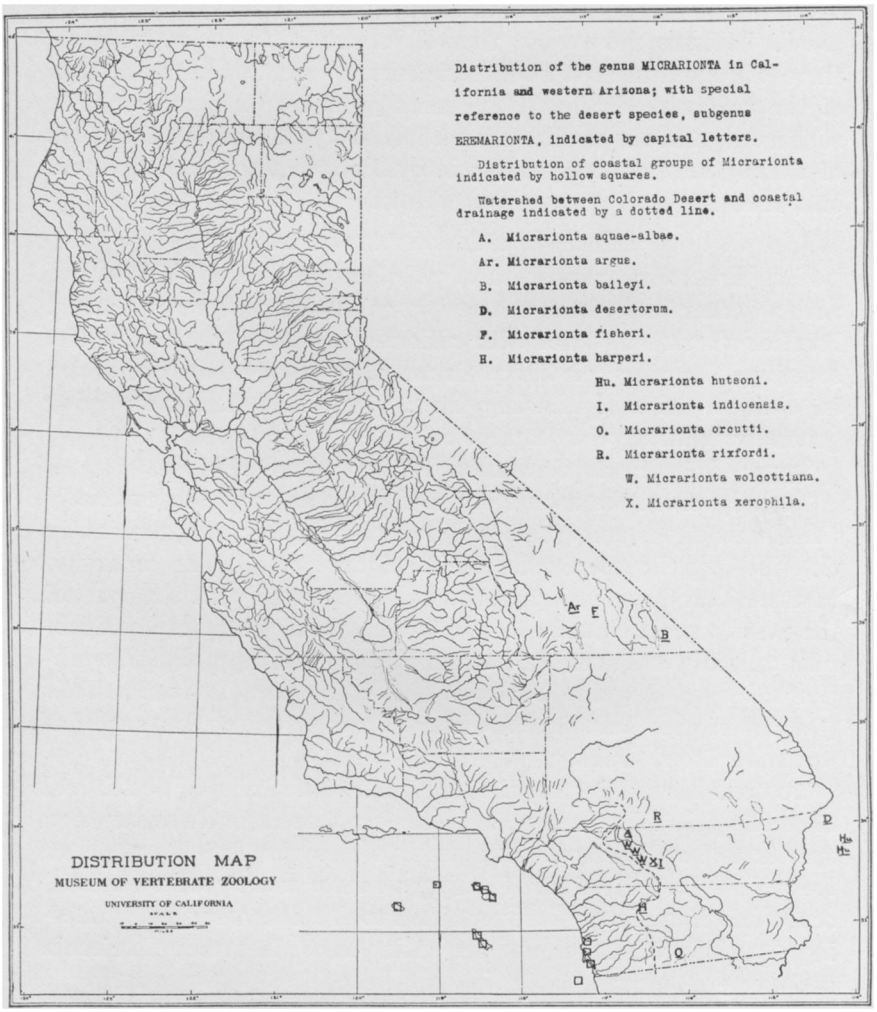
Station XVII. Base of San Jacinto Mts. just west of entrance to Snow Creek Canyon; alt. 1,500 ft.; April 3, 1,920; moist slope with trees and much other vegetation, has appearance of fine snail country, but the most industrious stone turning and digging yielded scanty results.

4.—ANNOTATED LIST OF SPECIES.

HELICIDAE

Genus **MICRARIONTA** Ancy 1880

This group, long subordinated as a section or subgenus of



Distribution of genus *Micrarionta* in California and western Arizona, with special reference to the desert species, subgenus *Eremarionta* (indicated by capital letters).

Epiphragmophora, has recently been elevated on anatomical

grounds to full generic rank by Pilsbry and Ferriss (:08, p. 135–136), who refer to it not only the typical species found on the southern California coast and islands, but also the desert forms of the Colorado basin. Tentatively admitting the propriety of this arrangement, at least until the proper relationship of all the western dart-bearing Helices to the more austral true *Epiphragmophoras* becomes more clear than I believe it to be at present, there still seem to exist abundant reasons for a further separation of the two very distinct Californian groups of *Micrarionta* into subgenera. All the species known fall easily into one or the other of these, the maritime species into *Micrarionta* s. s., the desert ones into Pilsbry's group *Eremarionta*.

Subgenus EREMARIONTA Pilsbry 1913

Shell almost always whitish or pale fawn colored or light brown, with a darker band above the periphery. Spiral sculpture wanting. Nuclear whorls sculptured with curiously formed, elongate papillae, sometimes bearing hair-like periostracal projections, and arranged in oblique, forward slanting lines, the radial sculpture being generally relatively inconspicuous.

Type: *Micrarionta desertorum* Pilsbry and Ferriss.

To judge from the nature of the shell characters, and especially the details of the embryonic sculpture, all the following previously described species seem referable to *Eremarionta*. The anatomy, however, has been investigated (by Pilsbry) only in the case of the first three: *Micrarionta desertorum* Pilsbry and Ferriss, *Sonorella wolcottiana* Bartsch, *Micrarionta hutsoni* Clapp, *Epiphragmophora harperi* Bryant, *Sonorella* (*baileyi*) *orcutti* Bartsch, *Helix* (*Carpenteri*, var.) *Indioensis* Yates, *Sonorella argus* Edson, *Micrarionta rixfordi* Pilsbry.

To these should logically be added *Sonorella baileyi* Bartsch and *Sonorella fisheri* Bartsch, which I have not seen, and the two new species to be described, with perhaps also the *Epiphragmophora bowersi* Bryant, the whole forming a rather weakly differentiated concourse of species entirely confined to the desert regions bordering the Colorado River and its basin, in southeastern California and western Arizona.

On the other hand the species of typical *Micrarionta* are all maritime and in their distribution well separated from the *Eremarionta* group, unless, as there are reasons for suspecting, the numerous Lower California Helices now generally referred to *Sonorella*

actually prove to be true Eremariontas, which would cause the areas inhabited by the two groups slightly to overlap. So far as at present known, *Micrarionta* s. s. is confined to the islands and adjacent mainland of California and northern Lower California. The typical *section* seems now to be restricted to the islands the section *Xerarionta* alone occuring upon both islands and mainland. An examination of these maritime forms shows that although subject to much variation in form and sculpture as among themselves, so as to fall readily into several fairly well delimited subgroups, they all agree in having a nuclear sculpture of simple, wavy, or anastomosing radial riblets, often obsolete, but not papillose or only obscurely so, and never, so far as I have been able to discover, showing a definite system of elongate papillae as in the desert species.

Eremarionta, then, is evidently wholly and characteristically Lower Sonoran in a faunal sense. It is probably also, at least in large degree, characteristic of what mammalogists and others have denominated the Rupestrine association of that zone.

Possibly both groups will eventually find a place as subgenera of one of the other West American genera.

Micrarionta aquae-albae new species. Plate VIII, fig. 2; Plate IX, figs, 2–6.

Shell small, thin, depressed-conic, umbilicate, the umbilicus deeply permeable, its diameter contained about six times in that of the shell. Whorls four, convex, subcarinate, with deeply channeled sutures, the last whorl only slightly descending in front. Aperture ample, obscurely angulate at the periphery, strongly oblique, its deflection about 40°. Peristome thin, sharp, not reflected except slightly at the umbilicus, its edges strongly converging and connected by a thin parietal callus. Periostracum slightly dehiscent, rather harsh and coarse for the size of the shell, being roughened not only by the lines of growth, but by a very close, fine, everywhere persistent, radial wrinkling, and by an overlying system of small papillae, which are elongate and so crowded as to be almost anastomosing on the first whorl, subsequently becoming more distinct, granular in appearance, and evidently ranked in fairly well defined, forward slanting lines. Papillae on body whorl show a progressively less regular arrangement until on the base they become smaller and more crowded and their linear arrangement is no longer evident. Color of dry shell near Saccardo's umber of Ridgway, slightly lighter below, with a narrow, very obscure sepia band just above the periphery. Body whorl of shell on living animal snuff brown, with sepia spots where mantle pigment shows through. Color of animal,—upper portion of body slate, the margins neutral gray; mantle a little

lighter than "pale grayish vinaceous," conspicuously maculated or spotted with slate on surface next shell; sole of foot light mouse gray, shading at edge to neutral gray.

	Maximum Diameter mm.	Minimum Diameter mm.	Altitude mm.	Diameter Umbilicus mm.	Number of Whorls
Type	7.7	6.6	4.5	1.2	4
Paratype (largest dead shell)	7.6	6.6	4.5	1.3	4
Paratype	6.5	5.4	3.5	1.2	3¾
Paratype (dead shell)	7.0	5.7	3.7	1.2	3¾
Station I (live shell)	7.4	6.2	4.3	1.2	4
Station I (dead shell)	7.3	6.1	4.0	1.2	4

Type: Berry Collection Cat. No. 4,890. Paratypes in the museum of The Academy of Natural Sciences of Philadelphia, The California Academy of Sciences, and the private collection of Allyn G. Smith.

Type locality: Station II; among loose leaves and mould under a small tree (probably *Rhus* sp.,) in gulch on east side of Whitewater Canyon, near first bend to west, alt. ca. 1,800 ft.; San Bernardino Mountains, California; April 1, 1920; 4 living, 21 dead shells. Also Station I; talus slope on west side of Whitewater Canyon, about 1 mile above mouth; alt. ca. 1,700 ft.; San Bernardino Mountains, California; April 1, 1920; 1 living, 17 dead shells.

Unassuming enough at first glance and even reminding one somewhat of some of the common small land snails of the type of *Gonyodiscus*, or of certain of the lesser Arizonian *Oreohelices*, close inspection reveals this little snail as very distinct from all described American species. Its harshly shagreened periostracum, though furnishing almost its only striking specific character, is unlike that of any other snail I have noticed. This feature is evidently but an elaboration of the type of sculpture so characteristic of the earlier whorls in such species as *hutsoni*, *wolcottiana*. Hence it seems appropriate to refer the species, at least until its anatomy can be investigated, to *Eremarionta*.[4] All its other features, coarse periostracum, texture of shell, and particularly the conspicuously spotted mantle, must be confessed to resemble those of no other *Eremarionta* which has been described, being more like these of some of the species of the *Helminthoglypta* group.

[4]A dissection made by Dr. H. A. Pilsbury since this paper went to press has shown this species to possess the usual genitalia of *Micrarionta*.

Micrarionta wolcottiana (Bartsch 1903) Plate I, fig. 3.

? 1890. *Helix Traskii*, form, Orcutt, Nautilus, vol. 4, p. 67 (recorded from Palm Canyon and Snow Creek.)
1903. *Sonorella walcottiana* Bartsch, Proc. Biol. Soc. Wash., vol. 16, p. 103.
1904. *Sonorella wolcottiana* Bartsch, Proc. Biol. Soc. Wash., vol. 17, p. 101. (emended spelling).
1904. *Sonorella wolcottiana* Bartsch, Smiths, Misc. Coll., vol. 47, p. 187, 188, pl. 28; pl. 31, fig. 4.
1905. *Sonorella wolcottiana* Pilsbry, Proc. Ac. Nat. Sci. Phila., 1905, p. 254 (passing mention).
1908. *Micrarionta wolcottiana* Pilsbry & Ferriss, Nautilus, vol. 21, p. 135 (brief note).
1918. *Micrarionta wolcottiana* Pilsbry, Proc. Ac. Nat. Sci. Phila., 1918, p. 139, text fig. 1 (anatomy).
1921. *Micrarionta wolcottiana* Pillsbry, Nautilus, vol. 35, p. 48 (noted north of Palm Canyon).

The shell of this species has already been well described and figured by Bartsch (:03, :04a) although many more figures will be required to show the remarkable variations to which even the members of a single colony are subject. Certain anatomical features of taxonomic importance have likewise received treatment at the competent hands of Pilsbry (:18). To the published information the following color notes on the shell and animal may well be added.

The body of the living animal is Chaetura drab passing to drab at the margin, and with a narrow stripe of hair brown along the mediodorsal line. The sole is wood brown shading to avellaneous at the margin. The shell on the living animal is white (on its thicker portions), passing through vinaceous buff and intermediate shades to hair brown. The empty shell of the adult is light in tone, the body whorl varying from Tilleul buff to avellaneous, paling on the spire to cartridge buff or almost to pinkish buff, and in the immediate vicinity of the umbilicus to pale vinaceous fawn or almost white. The shoulder band, usually bordered above and below by a similar band of whitish, is quite a dark liver brown, often showing a sort of breaking up into two components, the darker one appearing with odd effect to overlie a lighter and brighter one of cinnamon rufous tone, Young and immature shells before the formation of the peristome are invariably much darker and brighter in color than the adults, the body of the shell a rather light snuff brown, toning to avellaneous on the spire and vinaceous buff at the umbilicus.

Fifteen specimens in the collection of Allyn G. Smith yield the following caliper measurements:

Locality	Maximum Diameter mm.	Minimum Diameter mm.	Altitude mm.	Diameter Umbilicus	Condition of Umbilicus
Murray Canyon.. ..	24.0	19.8	15.1	——	nearly covered
Murray Canyon.. ..	23.2	20.4	15.5	——	nearly covered
Murray Canyon.. ..	21.5	17.5	12.7	2.0	partly covered
Murray Canyon.. ..	20.7	17.0	13.2	2.0	partly covered
Murray Canyon.. ..	20.2	17.1	13.4	1.8	partly covered
Murray Canyon.. ..	19.0	15.8	11.6	1.8	partly covered
Tahquitz Canyon..	25.3	20.6	15.5	2.3	partly covered
Tahquitz Canyon..	24.6	20.5	18.5	——	covered
Tahquitz Canyon..	24.7	20.2	15.3	——	covered
Tahquitz Canyon..	20.7	17.2	13.6	1.5	partly covered
Tahquitz Canyon..	20.3	16.7	14.1	——	nearly covered

Aperture deflection of last specimen mentioned in table, 50°. Material has been examined as follows:

No. Specimens	Locality	Altitude	Collector	Date	Condition
3	Base of San Jacinto Mts., W. of Snow Cr. Canyon	1,500 ft.	Sta. XVII	Apr. 3, 1920	dead
7	Slope back of Palm Springs, San Jacinto Mts.	500 ft.	Geo. Willett	Mar. 18, 1919	living
9	do	" ft.	A. G. Smith	Mar. 25, 1920	1 living
6	do	" ft.	Sta. IV	Apr. 1, 1920	dead
100⅝	Entrance to Tahquitz Canyon, San Jacinto Mts.		A. G. Smith	Mar. 25, 1920	living
16	Murray Canyon, San Jacinto Mts.	1,500–2,000 ft.	A. G. Smith	Mar. 24, 1920	living
9	West Fork Palm Canyon, San Jacinto Mts.	750 ft.	Sta. IX	Apr. 2, 1920	dead
12	West side PalmCanyon, San Jacinto Mts.	100–1,100 ft.	Sta. X	Apr. 2, 1920	dead
20	East side Palm Canyon, Santa Rosa Mts.	900–1,300 ft.	Sta. XI	Apr. 2–3, 1920	2 adults 1 juv. living
1	Little Palm Canyon, Santa Rosa Mts.	1,200 ft.	Sta. XIV	Apr. 3, 1920	dead
2	Promontory E. of Palm Valley, Santa Rosa Mts.	500 ft.	Sta. VIII	Apr. 2, 1920	dead

One of the principal objects of our expedition of April, 1920, was to establish certain facts regarding the range of this most conspicuous of the desert snails. While its extreme limits were probably not ascertained, we collected it at many stations, from Station VIII on the promontory at the mouth of Palm Valley on the east, up Palm Canyon and Little Palm Canyon to Stations XI and XIV, and thence around Palm Valley via Stations XII, IX, and IV to Palm Springs, and then again at Station XVII on the slope just west of the entrance to Snow Creek Canyon, well up into the San Gorgonie Pass. Mr. Smith had previously collected the species in some numbers in the lower part of Murray

Canyon (on both slopes), and more especially at the mouth of Tahquitz Canyon. He must have happened on a remarkably favored location at a fortunate time, for on the later expedition we failed to meet with living specimens in any numbers anywhere, whereas only a week before he had taken over a hundred in the open at the latter locality alone. On that occasion he found the snails abundant and crawling actively on the surface among big slabs of granite and under bushes on quite a moist slope, where they seemed to constitute quite a definite colony. The time was between 8:00 and 9:30 A. M. In Murray Canyon where he had collected the previous afternoon, Mr. Smith found dead shells fairly common on both slopes of the canyon along its lower course, but live shells were only scattering and mostly to be found under stones, indeed only one being found crawling on the surface. In this canyon he could detect no indication of any association in colonies, and we found conditions in Palm Canyon altogether similar in this respect. The slope back of the Palm Springs Hotel, which, by the way, impressed us as by no means the best collecting ground, is reputed to be the type locality. This was our Station IV, or at any rate not far from it.

Orcutt ('90, p. 67) has already recorded a snail which he collected at Snow Creek Canyon as *Helix traskii*, but at that time the peculiarities of the desert snails were little understood, and I think there is small doubt that his shells were really *wolcottiana*. The fact that we collected indubitable specimens of the species so near there and actually to the west supports this contention. True *Epiphragmophora traskii* is still unknown from the desert drainage.

As is brought out in the table of measurements, *wolcottiana* is an extremely variable species even within the confines of a single circumscribed colony like that found at the mouth of Tahquitz Canyon. Some are fairly depressed, some strongly elevated, some large, some with less than one-half the bulk, some extremely thin, some thick and heavy, some with the narrow umbilicus left nearly free, others with it entirely closed, and so on. The color of the animal, too, shows a considerable range of variability, though always strikingly different from that, for instance, of the following species. On the other hand the shells of adults vary little in color. Young shells are always much darker and brighter than adults, their bright snuff brown color being quite unlike that of any other species of desert snail.

The canyons inhabited by this snail are generally noteworthy for their growth of the palm, *Neowashingtonia*, but the palms occur principally in close proximity to the creek bed, while the snails inhabit the immediately adjacent slopes.

Micrarionta xerophila new species. Plate X, figs. 1-4.

Shell strongly depressed, of moderate weight; whorls convex; sutures distinct; last whorl strongly descending behind peristome. Umbilicus of moderate width, being contained about seven times the diameter of the shell, funicular, permeable. Aperture strongly oblique, its deflexion about 45°. Peristome distinctly thickened, its margin somewhat reflected, especially near the umbilicus, the circular outline of which, however, is scarcely affected. Nuclear whorls heavily covered with elongate, moderately crowded papillae, more or less distinctly ranked in oblique, forward slanting lines; subsequent whorls showing gradually smaller, more granular, and less crowded papillae, which finally become practically obsolete on the body whorl both above and below. Spiral sculpture wanting. Periostracum, except for the papillae and numerous fine lines of growth, smooth, thin, lustrous. Shell moderately to conspicuously encircled by a narrow band, 0.5–1.0 mm. wide, varying in color from deep brownish vinaceous in light toned shells, to liver brown in darker ones, this band bordered above and below by very light bands about twice as wide, which vary from white to light ivory yellow; base of shell pale grayish vinaceous to avellaneous; region below suture pale grayish vinaceous to deep brownish vinaceous; shell on living animals pale olive buff, passing to cinnamon drab near suture, often much mottled or clouded. Body of animal varying from slate black to black, shading slightly lighter toward margin; mantle neutral gray to slate gray, without conspicuous pigment patches; sole of foot deep neutral gray, shading rather abruptly to blackish slate at margin.

	Maximum Diameter	Minimum Diameter	Altitude	Diameter Umbilicus	Number of Whorls
	mm.	mm.	mm.	mm.	
Paratype (dead shell)..	17.0	14.0	10.1	2.4	4¾
Paratype, Smith Coll...	16.8	13.8	9.3	2.3	4¾
Paratype (dead shell)..	16.3	13.5	10.3	2.3	4⅞
Type.....	16.7	13.5	9.2	2.3	4½
Paratype.....	14.0	11.7	8.2	2.0	4½

Type: Berry Collection Cat. No. 4,888. Paratypes in the museum of The Academy of Natural Sciences of Philadelphia, the California Academy of Sciences, and the private collection of Allyn G. Smith.

Type Locality: Station VII; in crevices and under stones on slope on Ocean to Ocean Highway, 5 miles west of Indian Well, Riverside County, California; alt. 400–600 ft.; April 2, 1920, 4

living, 18 dead shells. Also found 1 mile south of Indian Well, Riverside County, California; George Willett, March, 1919; 6 living specimens.

This very attractive little snail in many respects recalls Pilsbry's description of his *Micrarionta rixfordi*, but the umbilicus is narrower, and the sculpturing of the earlier whorls evidently quite different. As the two species come from different mountain systems, with the whole upper Cahuilla Basin between, it is doubtful if they are as nearly allied as the descriptions superficially indicate. To my notion, *M. indioensis* is really the nearest akin to *xerophila* of any of those previously described. Its larger size, more elevated outline, and narrower umbilicus serve to distinguish it, but it is the same general type of shell, and it may be that enough intergrades will come to light in intervening territory to reduce *M. xerophila* to the status of a subspecies. In fact, the small series of snails above noted which Mr. Willett collected to the south of Indian Well may represent one of the intermediate forms, as his specimens, though surely not all typical of *indioensis*, are yet not quite characteristic of *xerophila*. It seems best to refer them to the latter species at least tentatively, as the available information regarding the possible limits of variation in all these forms is still very scanty.

The dead shells were either picked up on the surface or from among loose soil and rocks, but living ones could be obtained only by digging out the loose detritus in the lee of large rocks, following up crevices, or turning stones. They were generally within a few inches of the surface, and wherever deeper digging was attempted we met with no success.

Micrarionta indioensis (Yates 1890)

1889. New species of *Helix* Orcutt, W. Am. Sci., vol. 6, p. 96 (brief note).
1890. *Helix Carpenteri* var., Yates, Nautilus, vol. 4, p. 51.
1890. *Helix* (*Arionta*) *Carpenteri* var. *Indioensis* Yates, Nautilus, vol. 4,p. 63.
1890. *Helix Traskii*, form, Orcutt, Nautilus, vol. 4, p. 67.
1891. *Helix Traskii*, var. *Indioensis* Orcutt, W. Am. Sci., vol. 7, p. 223 (brief note).
1892. *Helix rowellii* (pars) Cooper, Zoe, vol. 3, p. 19 (brief note).
1894. *Epiphragmophora indioensis* Pilsbry, Man. Conch., (2), vol. 9, p. 199 (teste Bartsch).
1896. *Epiphragmophora indioensis* Dall, Proc. U. S. Nat. Mus., vol. 19, p. 337, 366 (brief note).
1897. *Epiphragmophora indioensis* Pilsbry, Nautilus, vol. 11, p. 59 (merely catalogued).
1898. *Epiphragmophora indioensis* Pilsbry, Cat. Am. Land Sh., p. 5 (merely catalogued).

1900. *Sonorella indioensis* Pilsbry, Proc. Ac. Nat. Sci. Phila., 1900, p. 550 (passing mention).
1904. *Sonorella indioensis* Bartsch, Smiths, Misc. Coll., vol. 47, p. 187, 189, pl. 33, fig. 1.
1908. *Micrarionta indioensis* Pilsbry & Ferriss, Nautilus, vol. 21, p. 135 (brief note).

This is the longest known of the desert Helices, yet does not seem to have been collected many times, and I cannot find that living specimens have ever been taken. In spite of much exertion, we ourselves were no more fortunate than our predecessors in this respect. The type locality is said to be "near Indio," but without doubt this can be emended to "south of Indio," rather than north, as the dead shells found by us in the cove back of Indian Well are, except for their slightly smaller size, so nearly typical as to indicate that the original specimens could not have been collected so very far away. At this point the steep slope is, at the present time, very dry, supporting only the scantiest vegetation, and even dead shells proved difficult to find, although occurring scattered loosely on the surface from near the base of the slope to the top of the ridge. Only 11 fairly good shells was the total catch of the party in an hour or so of work. This and *M. xerophila* appear to be species of the Santa Rosa Range; they are unknown from the San Jacintos.

The largest specimen at hand measures: maximum diameter, 18.6; minimum diameter, 15.1; altitude, 10.5; diameter of umbilicus, 2.0 mm. It has 4⅔ whorls.

Micrarionta harperi (Bryant 1900) Plate X, figs. 5–8.

1900. *Epiphramophora harperi* Bryant, Nautilus, vol. 13, p. 143.
1900. *Epiphragmophora Harperi* Bryant, W. Am. Sci., vol. 11, p. 30 (reprint of preceding).
1900. *Epiphragmophora Harperi* Orcutt, W. Am. Sci., vol. 11, no. 91, p. 70; no. 92, p. 28 (brief note).

Shell strongly depressed, of moderate weight; whorls convex; sutures distinct; last whorl strongly descending behind peristome. Umbilicus wide and deep, contained about six times in the diameter of the shell, funicular, permeable, all the whorls easily visible to the apex. Aperture strongly oblique, its deflexion about 45–50°. Peristome but little thickened hardly reflexed except slightly at the umbilicus, which it barely indents. Nuclear whorls heavily covered with narrow, elongate papillae, ranked in oblique, forward slanting lines so close together as to be almost or quite confluent, the lines thus being transformed practically into low lirae; papillae on subsequent whorls less crowded and always smaller and rounder than the foregoing, being very obscure on the upper surface of the

last turn, minute, well spaced, and granular on almost the whole of the basal surface. Spiral sculpture wanting. Periostracum, except for the papillae and numerous fine lines of growth, smooth, thin, and lustrous. Shell white or very light ivory yellow, passing to avellaneous on the spire; a narrow fawn band, about 0.7 mm. wide encircling the shoulder, flanked both above and below by an obscure whitish band of approximately the same width.

	Maximum Diameter mm.	Minimum Diameter mm.	Altitude mm.	Diameter Umbilicus mm.	Number of Whorls
Cal. Ac. Sci. 8,676A...	15.5	13.0	8.5	2.5	4¾
Berry Coll. 4,767.....	15.0	12.5	8.2	2.4	4¾

Type Locality: "San Jacinto Mts., California" (Bryant).

Material has been examined as follows:

No. of Specimens	Locality	Collector	Where Deposited
4	Warner's Hot Springs, San Diego Co., Cal.	F. W. Bryant	Cal. Ac. Sci. 8,676A
2	do	F. W. Bryant	Berry Coll. 4,767

On a visit to the California Academy of Sciences in San Francisco a year or two ago, it was a matter of great interest to discover among the material acquired by the Academy from the collection of the late Henry Hemphill, a small series of the little-known *Epiphragmophora harperi* Bryant, evidently authentic since received from Bryant himself. As the original description was only a short notice of a few lines, and nothing further regarding the species was ever published, I have ventured to redescribe it and to add figures of the best of the Academy specimens. More important still it is now possible to give Warner's Hot Springs as the locality, perhaps even the original locality, where the species was found, Bryant having obscurely recorded it as "San Jacinto Mts." Such descriptions and records surely were better never published, as they are sure to lead to misunderstandings and confusion, and much laborious research and waste of time to unravel the tangle. If the present specimens are truly originals, the present species can be established as a typical *Eremarionta*, although the peculiarities of the sculpture on the early whorls seem to have been pushed farther than in any other of the described species. *M. orcutti* Bartsch, however, is very close to this, and when better material of it can be found, it may prove to be identical. *M. xerophila* is another somewhat similar species, but is smaller, has a more lively coloration, and the umbilicus is much narrower, besides there being manifest differences in the embryonic sculpture.

With Bryant's description, as far as it goes, the specimens examined show fair agreement. The chief discrepancies are in the number of whorls, which he gives as 5, his account of the first three whorls as smooth (conceivably because he did not use a sufficiently powerful lens), and, more disturbingly, his description of the peristome as "broadly expanded." He also states that the umbilicus is "about one-fifth" the diameter of the shell. I am hopeful that the slightly larger size of his type specimen as compared with the present specimens and its evidently more adult condition are sufficient to account for most of the contrariety.

Micrarionta orcutti (Bartsch 1904)

1904. *Sonorella baileyi orcutti* Bartsch, Smiths, Misc. Coll., vol. 47, p. 96, pl. 33, fig. 5.

The type locality of this species is given by Bartsch as simply "in the Colorado desert." I once asked Mr. C. R. Orcutt, who collected the original specimens, if he possessed any more explicit data than this regarding their source. He informed me that he was no longer entirely certain, but believed the specimens described came from near Mountain Springs, Imperial County. If so, it ought not to be very difficult to rediscover the species. An immature specimen from the original lot kindly given me by Mr. Orcutt (Berry Coll. Cat. No. 3204) shows that *orcutti* is a characteristic *Eremarionta* in fact dangerously near to *M.* (*E.*) *harperi* Bryant, which is four years antecedent.[5] The nuclear sculpture is eroded on this specimen, but in good material may show valid differences from the very peculiar ornamentation of *harperi*. In their proportions, depressed outline, and wide umbilicus, the shells of the two forms are very close.

Genus **HELMINTHOGLYPTA** Ancey 1887

Helminthoglypta tudiculata (Binney 1843) var.

1843. *Helix tudiculata* Binney, Bost. Jour. Nat. Hist., vol. 4. p. 360, pl. 20.

The occurrence of this characteristic species of the coastal and

[5] Were it not for this fact the inclusion of so many of the desert snails in *Micrarionta* would necessitate the renaming of this species, for the prior *Epiphragmophora orcutti* Dall 1904, belongs with *kellettii* and *stearnsiana* in Pilsbry's division *Xerarionta* of the former genus. There will, however, be plenty of time to suggest a name for it after the rediscovery of the type locality enables us to establish whether or not it is really taxonomically distinguishable from *M. harperi*.

interior valleys well within the desert drainage system[6] was wholly unexpected, but it is apparently a common species in Whitewater Canyon in the San Bernardino Mountains, where a live adult and 3 dead juvenals were taken at Station I, a live juvenal and 9 dead shells of various ages at Station II, and an adult bleached shell at Station III. None of the shells is of the typical coastal form, nor do they seem exactly referable to the *subdolus* or *rufiterrae* types of the San Jacinto and San Bernardino Valleys, but the material is insufficient to justify one's saying more.

ZONITIDAE

Genus **ZONITOIDES** Pilsbry

Zonitoides minuscula (Binney 1840)

1840. *Helix minuscula* Binney, Bost. Jour. Nat. Hist., vol. 3, p. 435, pl. 22, fig. 4.
1885. *Zonites minusculus* W. G. Binney, Man. Am. Land Sh., p. 19, 23, 25, 30, 31, 32, 35, 38, 57, *63*, 479, fig. 18–20.

Two specimens of this species were taken in the drift of Palm Canyon at Station XII.

LIMACIDEA

Genus **AGRIOLIMAX** Mörch 1868

Agriolimax sp.

Ten specimens of a small slug thought to be referable to this genus were taken on a moist slope in Little Palm Canyon, but the specific determination is still uncertain. They have been deposited in the collection of The Academy of Natural Sciences of Philadelphia.

PUPILLIDAE

Genus **GASTROCOPTA** Wollaston 1878

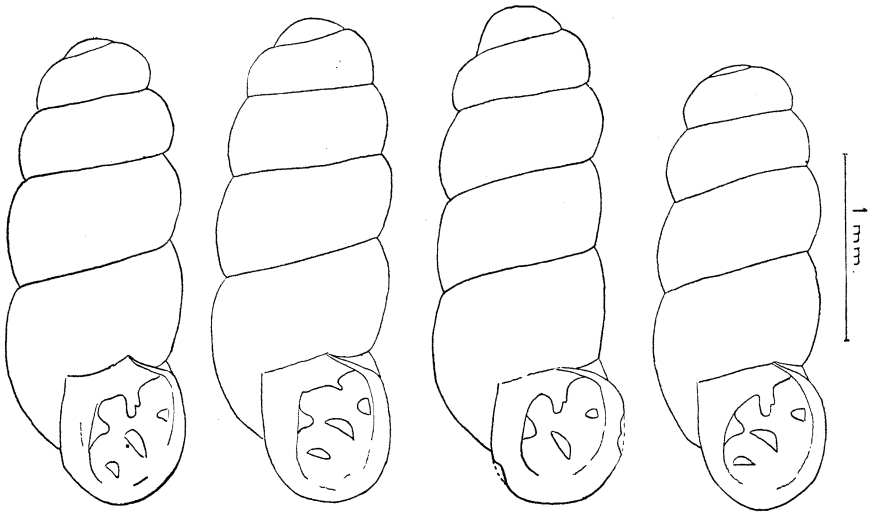
Gastrocopta pellucida hordeacella (Pilsbry 1890)

1890. *Pupa hordeacella* Pilsbry, Proc. Ac. Nat. Sci. Phila. 1890, p. 44, pl. 1, fig. g-k.
1916. *Gastrocopta pellucida hordeacella*, Pilsbry, Man. Conch., (2), vol. 24, p. 78, pl. 16; pl. 17, fig. 1–4.

A scant dozen specimens of this minute *Gastrocopta*, picked from

[6] It is appropriate to mention, however, that species of this genus must cross into the desert drainage at several points, for Mr. Smith has collected *H. cuyamacensis* in the wash at Warner's Hot Springs, and has found a large race of it (*H. c. lowei* Bartsch) at an elevation of 5,500 ft. on the east slope of Hot Springs Mountain in the same region.

the drift of Palm Canyon at Station XII, represent a small, narrow, quite evenly cylindrical form, somewhat different from the majority of Arizona specimens (e. g., drift of Salt River near Tempe, collected by L. E. Daniels; drift of San Pedro River near Benson, collected by H. A. Pilsbry and L. E. Daniels; foothills of Plumosa Range, Yuma County, collected by George S. Hutson) with which I have been able to compare them. Pilsbry's original figure, drawn from a Texas specimen, differs in much the same way. The material is, however, too scanty to be considered as showing that the Palm Canyon specimens belong to a race or subspecies really distinguish-



Figs. 1–4. *Gastrocopta pellucida hordeacella* (Pilsbry). Camera outlines of four specimens from Station XII, Palm Canyon, California, showing variation in contour of shell and form of denticles in aperture.

able from true *hordeacella*. The specimens are of most interest in that the known distribution of the group of Pupillidae which they represent is thus pushed many miles to the westward. Indeed it is thought that the species is recorded here from the state of California for the first time.

SUCCINEIDAE

Genus **SUCCINEA** Draparnaud 1801

Succinea avara Say 1824.

1824. *Succinea avara* Say, App. Long Exp., p. 2, 60, pl. 15, fig. 6.
1885. *Succinea avara* Binney, Man. Am. Land Sh., p. 31, 33, 36, 59, 337, *339*, 497, fig. 369.

Two small specimens of this widespread species were taken under sticks at the margins of a springy spot at Station XVI in Palm Canyon.

PHYSIDAE

Genus **PHYSA** Draparnaud 1901

Physa sp.

Specimens of a small *Physa*, which I have not ventured to determine specifically, were found at three stations in Palm Canyon: dead in the drift at Station XII, living among algae in Little Palm Creek (Station XIII), and in a spring at Station XV farther down the main canyon. At this last point they were noted to be quite abundant.

AMINICOLIDAE

Genus **PALUDESTRINA** d'Orbigny 1841

Paludestrina longinqua (Gould 1855)

1855. *Amnicola longinqua* Gould, Proc. Bost. Soc. Nat. Hist., vol. 5, p. 130.
1857. *Amnicola longinqua* Gould, Pac. R. R. Rep., vol. 5, p. 333, pl. 11, fig. 10–11.
1899. *Paludestrena longinqua* Pilsbry, Nautilus, vol. 12, p. 122.

A single minute shell taken in the drift of Palm Canyon at Station XII has somewhat the aspect of a small *Amnicola*, but is probably merely a juvenal of the widespread *P. longinqua*, so common in the semi-fossil state in the Cahuilla Basin, and known living from various localities in the Cuyamaca Mountains and elsewhere. A camera drawing of the present specimen is appended.

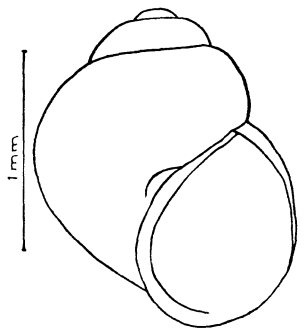


Fig 5. *Paludestrina longinqua* (Gould)? Camera outline of juvenal shell from Station XII, Palm Canyon, California.

Explanation of Plates VIII, IX, X.

Note: The microphotographs of periostracal sculpture reproduced in the accompanying plates were made by Mr. John Howard Paine. The remaining specimen photographs were made by Messrs. John Howard Paine and Berton W. Crandall. The illustrations on Plate VIII, and fig. 1 of Plate IX, are from field photographs taken by the author.

Plate VIII.—Fig. 1.—Lower Whitewater Canyon, San Bernardino Mountains, California, looking north. Stations I and III of the present paper are at the base of the canyon wall in the distance at the left. The two palms in the foreground are probably the westernmost endemic specimens of *Neowashingtonia filamentosa* Sudw. Photograph taken April 1, 1920.

Fig. 2.—South slope of small side canyon tributary to Whitewater Canyon, San Bernardino Mountains, California. Station II, the type locality of *Micrarionta aquae-albae*, is under the small tree to the right of the center of the picture. Photograph taken April 1, 1920.

Fig. 3.—Looking down Little Palm Canyon, Riverside County, California, from a point on the east wall above the junction with the main canyon; a characteristic habitat of the snail, *Micrarionta wolcottiana*. Stations XI and XIII are near the center of the picture. The desert slopes of the San Jacinto Range above Palm Springs loom in the background. Photograph taken April 3, 1920.

Plate IX.—Fig. 1.—Looking up the main fork of Palm Canyon, Riverside County, California, from a point near its junction with Little Palm Creek. The abundant palms are *Neowashingtonia filamentosa* Sudw. Stations X and XII are visible in the nearer distance. Photograph taken April 3, 1920.

Figs. 2–4.—*Micrarionta aquae-albae* n. sp. Three views of the type specimen, from Station II, Whitewater Canyon, California; x 4.

Fig. 5.—*Micrarionta aquae-albae* n. sp. Upper surface of part of body whorl of type specimen a little back of the aperture, greatly magnified to show the periostracal sculpture; enlarged about 18 diameters.

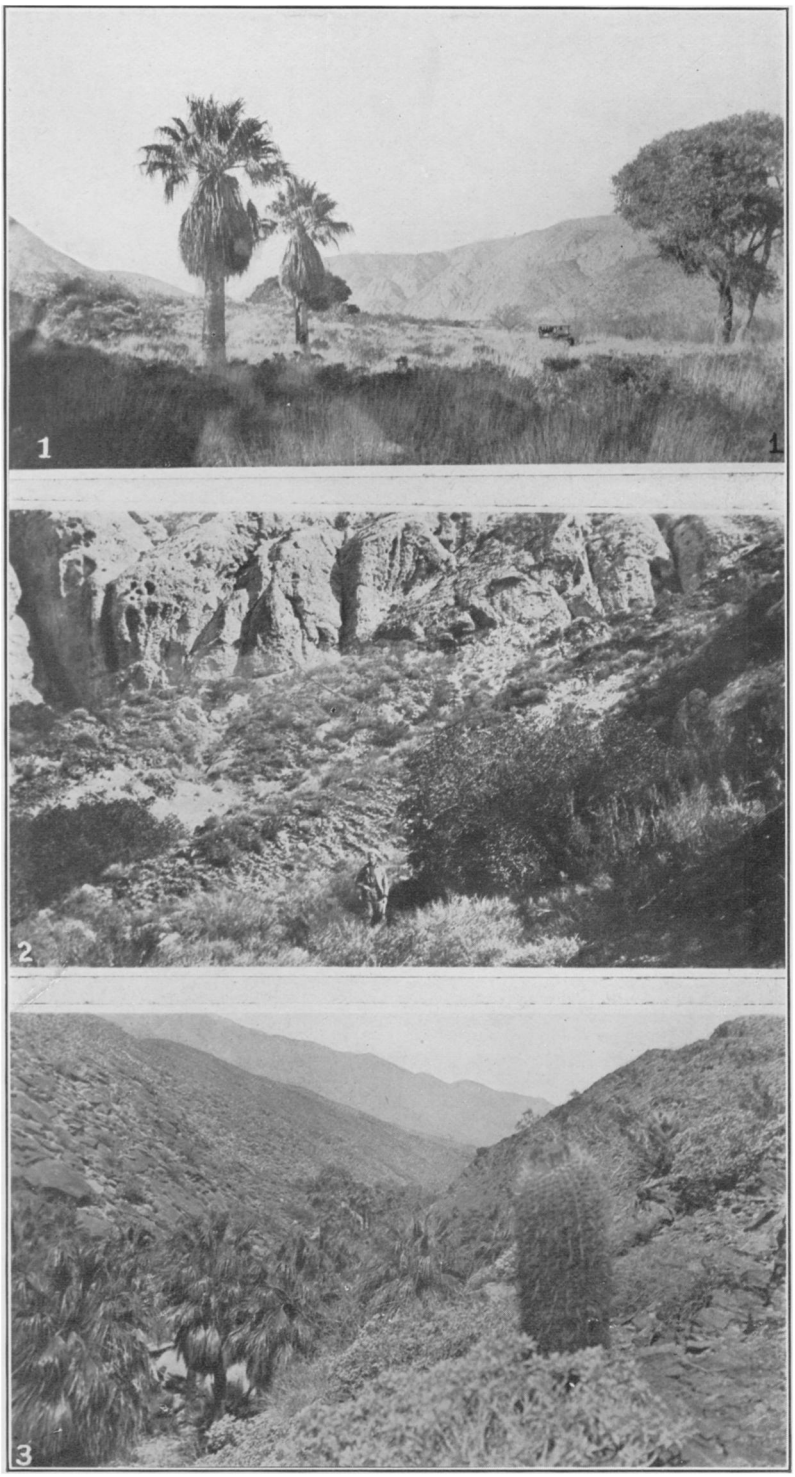
Fig. 6.—*Micrarionta aquae-albae* n. sp. Greatly magnified view of apical whorls of specimen from Station I, Whitewater Canyon, California, showing the periostracal sculpture; enlarged about 18 diameters.

Plate X.—Figs. 1–3.—*Micrarionta xerophila* n. sp. Three views of type specimen from Station VII, west of Indian Well, California; x 2.

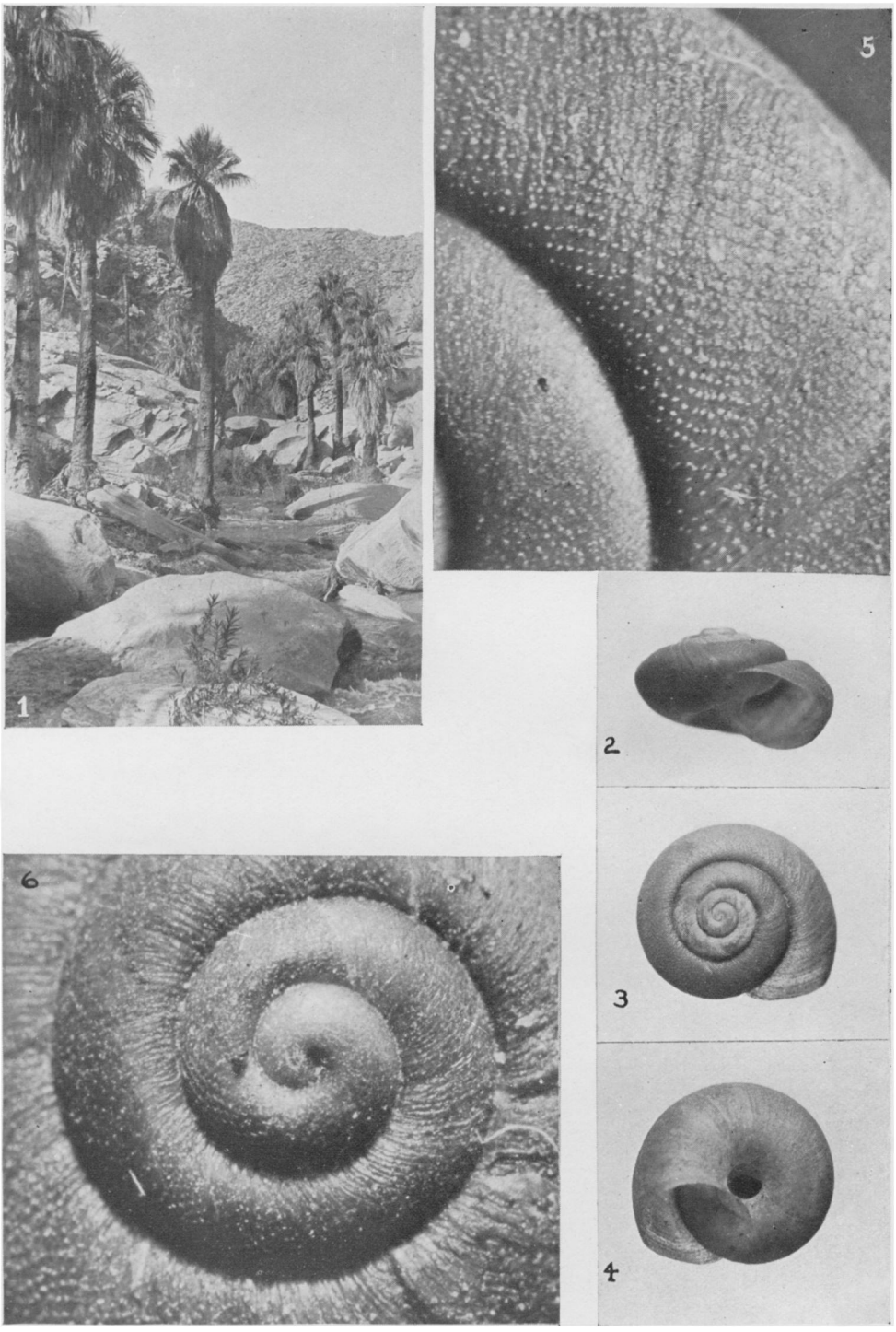
Fig. 4.—*Micrarionta xerophila* n. sp. Greatly magnified view of apical whorls of type specimen, showing the periostracal sculpture; enlarged about 19 diameters.

Figs. 5–7.—*Micrarionta harperi* Bryant. Three views of specimen collected by Bryant at Warner's Hot Springs, California; Cal. Ac. Sci. 8676A; x 2.

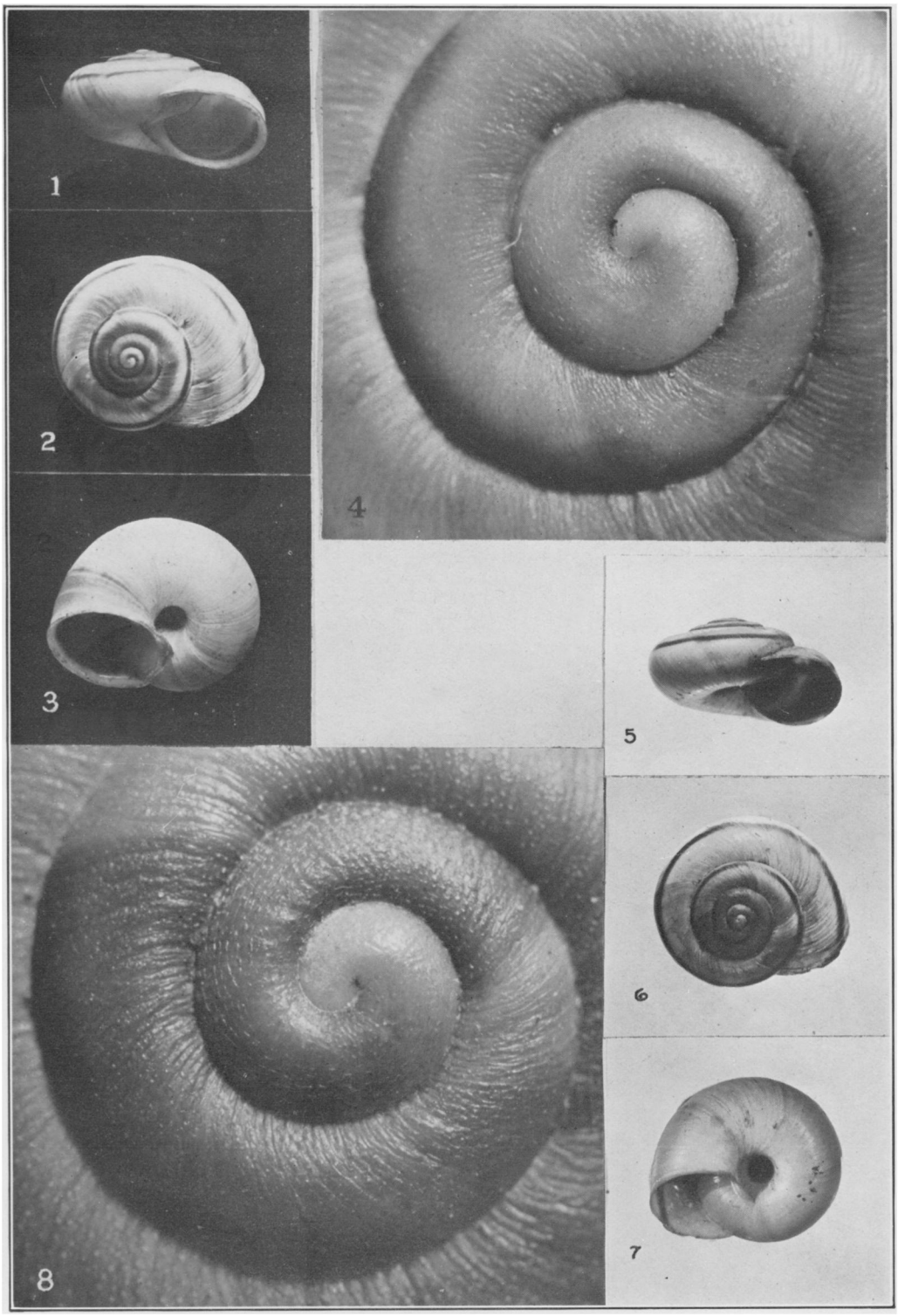
Fig. 8.—*Micrarionta harperi* Bryant. Greatly magnified view of apical whorls of same specimen, showing the periostracal sculpture.



BERRY: MOLLUSKS OF THE COLORADO DESERT,—I.



BERRY: MOLLUSKS OF THE COLORADO DESERT,—I.



BERRY: MOLLUSKS OF THE COLORADO DESERT,—I.